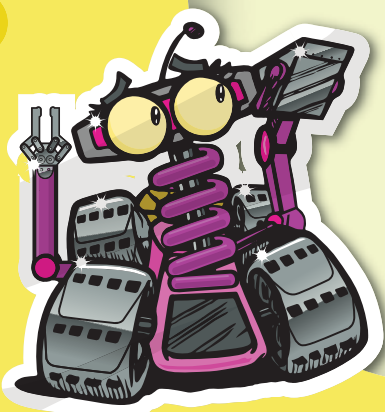


ROBOTIC MINING COMPETITION

NASA's Robotic Mining Competition is a university-level competition designed to engage and retain students in science, technology, engineering and mathematics (STEM). The challenge is for students to design and build a mining robot that can traverse the simulated Martian chaotic terrain, excavate Martian regolith and deposit the regolith into a Collector Bin within 10 minutes. There is particular relevance to NASA's mission of pioneering a human presence on Mars through resource mining and utilization. A critical resource on Mars is water ice which can be found buried in the regolith where it is well insulated. The technology concepts developed by the university teams for this competition conceivably could be used to robotically mine regolith resources on Mars. NASA will directly benefit from the competition by encouraging the development of innovative robotic excavation concepts from universities which may result in clever ideas and solutions which could be applied to an actual excavation device or payload. The unique physical properties of basaltic regolith and the reduced $\frac{3}{8}$ th of Earth gravity make excavation a difficult technical challenge. Advances in Martian mining have the potential to significantly contribute to our nation's space vision and NASA space exploration operations.



AWARDS

GRAND PRIZE: THE JOE KOSMO AWARD FOR EXCELLENCE

The Joe Kosmo Award for Excellence is given to the team that scores the most points during the competition. Winners will be given a school trophy and a \$5,000 team scholarship.

ON-SITE MINING AWARD

1st Place: \$3,000 team scholarship

2nd Place: \$2,000 team scholarship

3rd place: \$1,000 team scholarship

SYSTEMS ENGINEERING PAPER COMPETITION

\$500 team scholarship

OUTREACH EDUCATION PROJECT REPORT

\$500 team scholarship

SLIDE PRESENTATION & DEMONSTRATION

\$500 team scholarship

SOCIAL MEDIA & PUBLIC ENGAGEMENT

\$500 team scholarship

JUDGES INNOVATION AWARD

The team with the most innovative design will receive the Judges' Innovation Award at the discretion of the mining judges.

EFFICIENT USE OF COMMUNICATIONS POWER AWARD

The team using the least amount of average bandwidth during the timed and NASA monitored portion of the competition will be awarded the Efficient Use of Communications Power Award.

Teams must collect the minimum 10 kg of BP-1 to qualify for this award.

THE REGOLITH MECHANICS AWARD

Awarded to the team with the best example of a real granular innovation that identified a specific regolith mechanics problem (like the way the soil flows around the grousers, or angle of repose too high in their dump bucket, etc.) and intentionally improved their design to deal with it. Courtesy of the Center for Lunar and Asteroid Surface Science (CLASS), part of NASA's Solar System Exploration Research Virtual Institute (SSERVI) Network.

CATERPILLAR AWARD FOR AUTONOMY

1st Place: \$1,500 team scholarship

2nd Place: \$750 team scholarship

3rd place: \$250 team scholarship

ITINERARY

Monday May 22

7am Team Check-In Opens
7am RobotPits Open
9am Robot Inspections Open
Noon Lunch
1pm Practice Runs Begin
3pm Team Check-In Closes
7pm RoboPits Close

Tuesday May 23

7am Returning Robots Opens
7am RobotPits Open
7:30 Judge's Meeting
8am Practice Runs Begin
9am Returning Robots Check-In Closes
11am Opening Ceremony
Noon Lunch
1pm Practice Runs Begin
7pm RoboPits Close

Wednesday May 24

7am Returning Robots Opens
7am RobotPits Open
7:30 Judge's Meeting
8am Competition Runs Begin
9am Returning Robots Check-In Closes
Noon Lunch
1pm Competition Runs Begin
7pm RoboPits Close

Thursday May 25 – Media Day

7am Returning Robots Opens
7am RobotPits Open
7:30 Judge's Meeting
8am Women in STEM Mentoring Breakfast
Debus Conference Center
8am Competition Runs Begin
9am Returning Robots Check-In Closes
11am College Recruitment Fair
Noon Lunch
1pm Competition Runs Begin
7pm RoboPits Close

Friday May 26

7am Returning Robots Opens
7am RobotPits Open
7:30 Judge's Meeting
8am Competition Runs Begin
9am Returning Robots Check-In Closes
Noon Lunch
1pm Competition Runs Begin
1 pm Begin RoboPit Clear & Sweep
4pm Competition Runs End
7pm Award Ceremony Apollo-Saturn V

SPEAKER

ROBERT D. CABANA

Born in Minneapolis, Minn., Robert D. Cabana graduated from the U. S. Naval Academy in 1971 with a bachelor's degree in mathematics. He was commissioned a second lieutenant in the U.S. Marine Corps and completed Naval Flight Officer training in Pensacola in 1972. Cabana then served as an A-6 bombardier/navigator with Marine Air Wings in Cherry Point, N.C., and Iwakuni, Japan.

Returning to Pensacola in 1975, Cabana began pilot training and was designated a naval aviator in September of 1976, earning the Daughters of the American Revolution award as the top Marine to complete flight training that year. He graduated with distinction from the U.S. Naval Test Pilot School in 1981 and served in the Flight Systems Branch at the Naval Air Test Center until 1984. During his career, Cabana has logged over 7,000 hours in 50 different kinds of aircraft.



Cabana was selected as an astronaut candidate in June 1985 and completed his initial astronaut training in July 1986. He was assigned to the Lyndon B. Johnson Space Center Astronaut Office, serving in a number of leadership positions, including lead astronaut in the Shuttle Avionics Integration Laboratory; Mission Control Spacecraft Communicator, famously known as CAPCOM; and chief of NASA's Astronaut Office.

A veteran of four space flights, Cabana has logged 38 days in space, serving as the pilot on STS-41 and STS-53 and mission commander on STS-65 and STS-88. His fourth flight was the first assembly mission of the International Space Station in December of 1998. Following his retirement as a colonel from the Marine Corps in September 2000, Cabana was appointed a member of the Federal Senior Executive Service. He served in numerous, challenging, senior management positions at Johnson Space Center in Houston, ultimately becoming deputy director.

In October 2007, Cabana was appointed director of NASA's John C. Stennis Space Center in Mississippi. A year later he was reassigned as the tenth director of the John F. Kennedy Space Center. Cabana currently serves as director of NASA's John F. Kennedy Space Center in Florida. In his current role, Cabana manages all NASA facilities and activities at the spaceport, including the team of civil service and contractor employees who operate and support numerous space programs and projects.

Cabana's many achievements have been recognized with induction into the Astronaut Hall of Fame and being named an Associate Fellow in the American Institute of Aeronautics and Astronautics and a Fellow in the Society of Experimental Test Pilots. He has received numerous personal awards and decorations, including the Distinguished Flying Cross, the Presidential Distinguished Rank Award, and the National Space Club Florida Committee's Dr. Kurt H. Debus Award. He is also a recipient of the Rotary National Award for Space Achievement's National Space Trophy.

SPEAKER

STEVE SHOEMAKER



Steve Shoemaker is the Chief Engineer for Caterpillar's Excavation Division. Having spent 3 years living in Japan, he and his family have recently repatriated to the US and are now based in Peoria, Illinois. He is also Managing Director of the company's Hydraulic Excavator Development Center, which employs more than 600 engineers in Japan. In this role, Shoemaker manages a global product development organization with facilities in Japan, China, Germany, Belgium, India, and the USA. The team is dedicated to developing 11 to 90 ton tracked and wheeled excavators for Caterpillar customers around the world.

Shoemaker joined Caterpillar in 1989 as a design engineer in the company's engine business in Mossville, Illinois, USA. He spent the next 14 years in a variety of engine assignments ranging from design to marketing, including an overseas assignment in Geneva, Switzerland, where he worked with Caterpillar dealers throughout Europe, Africa, and the Middle East. In 2003, Shoemaker moved to the company's Electronics division and was responsible for engine and machine controls, power electronics, displays, and instrumentation. In 2006, Shoemaker was named Engineering Director for Caterpillar's Building Construction Products Division based in Clayton, North Carolina. Over the next six years, Shoemaker worked to establish a dedicated engineering organization with teams in England, India, China, Japan, and the USA.

Shoemaker holds a Bachelors of Science degree in Mechanical Engineering from the South Dakota School of Mines and Technology and a Masters Degree in Business Administration from Purdue University.

SPEAKER

JOE KOSMO

In 1961, Joseph J. Kosmo earned a bachelor of science in aeronautical engineering at the Pennsylvania State University, University Park, Pennsylvania, and in 1978, he received a master of science in Environmental Management from the University of Houston – Clear Lake in Houston, Texas. His career at NASA began on November 21, 1961 as an aerospace technologist with the Crew Equipment Branch, Life Sciences Division, Space Task Group, at Langley Field, Virginia. During his time with NASA, Kosmo supported the Manned Spacecraft Center at JSC and worked with spacesuits for all NASA flight programs including Mercury, Gemini, Apollo, Apollo-Soyuz Test Project (ASTP), Skylab, Shuttle, and the ISS as well as numerous advanced technology configuration space suits.

This included being the NASA project engineer for the RX-series of hard suit development and the Mark III (MK III) 8.3 psi advanced space suit, as well as various advanced extravehicular glove concepts for future space mission applications. He was awarded six patents regarding extravehicular and spacesuit hardware related technology development and has written and coauthored numerous technical papers on spacesuits and space suit gloves. He has received the American Astronautical Society's Victor A. Prather Award twice for outstanding contribution in the field of EV protection in space, awarded the NASA Exceptional Service Medal and the Astronaut "Silver Snoopy" Award, and has been recognized by the U.S. Space Foundation Space Technology Hall of Fame for his work on the development of the liquid cooling garment for spacesuit and medical applications.

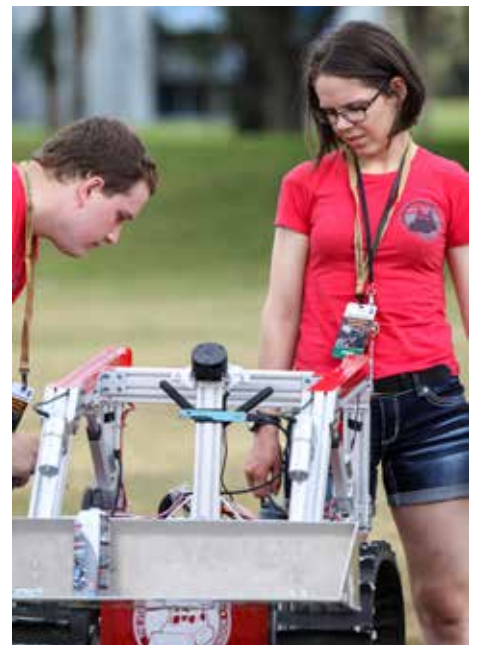
Before his retirement in December 2011 as a NASA Senior Project Engineer, he continued pursuing the development of advanced spacesuits and ancillary EVA supporting hardware concepts for future free-space and planetary surface exploration. Over a 14-year period (1997-2011), he organized and was Mission Manager for the NASA Desert Research and Technology Studies (D-RATS) activities. D-RATS was an integrated team of engineers and scientists from various NASA centers, industry and academia, which performed a series of simulated planetary mission remote field-site test activities of prototype EV hardware, spacesuit mobility studies, and rover and human/robot assistant vehicle interactive capabilities in a variety of planetary surface analog locations including Death Valley in the Mojave Desert, and northern Arizona.

After retiring from NASA, he formed the sole proprietorship "Devilsfork Consulting, LLC" in January of 2012 and since that time has acted as a consultant to NASA and the aerospace industry in the support of the development of advanced space suit technology for future human space flight goals and objectives.

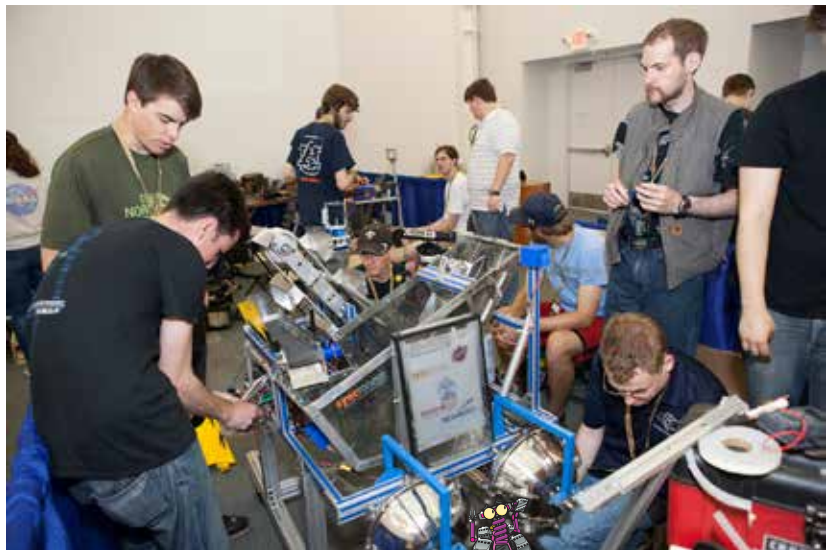
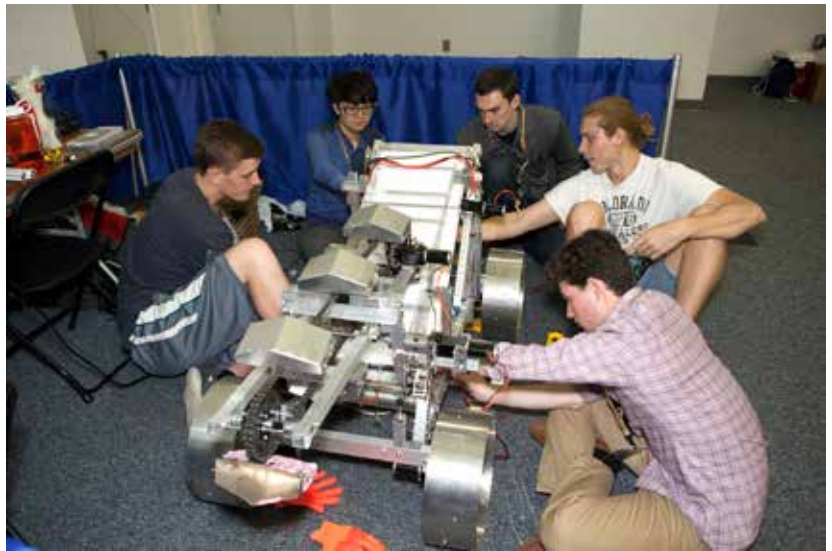


ROBOTIC MINING COMPETITION 2016









Teams 2017

Auburn University

Case Western Reserve University

Colorado School of Mines

Embry-Riddle Aeronautical University

Florida Institute of Technology

Illinois Institute of Technology

Iowa State University

John Brown University

Kent State University

Milwaukee School of Engineering

Mississippi State University

Montana State University

Montana Tech

**New York University's
Tandon School of Engineering**

North Dakota State University

Oakton Community College

Polytechnic University of Puerto Rico

Purdue University

South Dakota School of Mines & Technology

Temple University

Texas A & M International University

The University of Akron

The University of Alabama

The University of North Carolina at Charlotte

The University of Utah

University of Alaska Fairbanks

University of Arkansas

University of Central Florida

University of Colorado Boulder

University of Florida

University of Hawaii-Hilo

University of Illinois at Chicago

University of Illinois at Urbana-Champaign

University of Kentucky

University of Michigan

University of Nebraska-Lincoln

University of New Hampshire

University of North Dakota

University of North Florida

University of Virginia

University of Washington Bothell

University Wisconsin – Madison

Virginia State University

Virginia Tech

West Virginia University

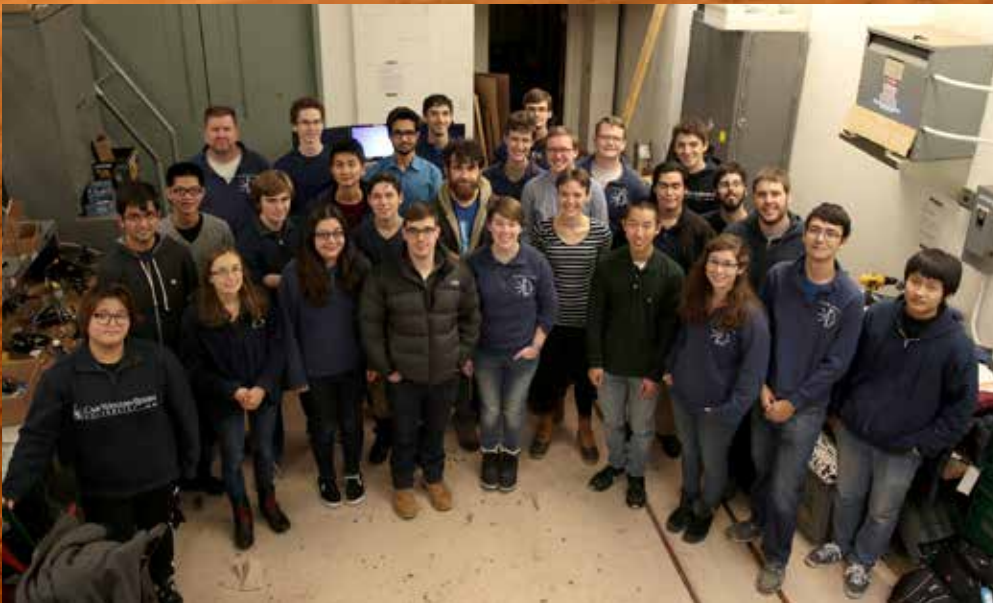
Worcester Polytechnic Institute

Wright State University

York College



Auburn University



Case Western
Reserve University

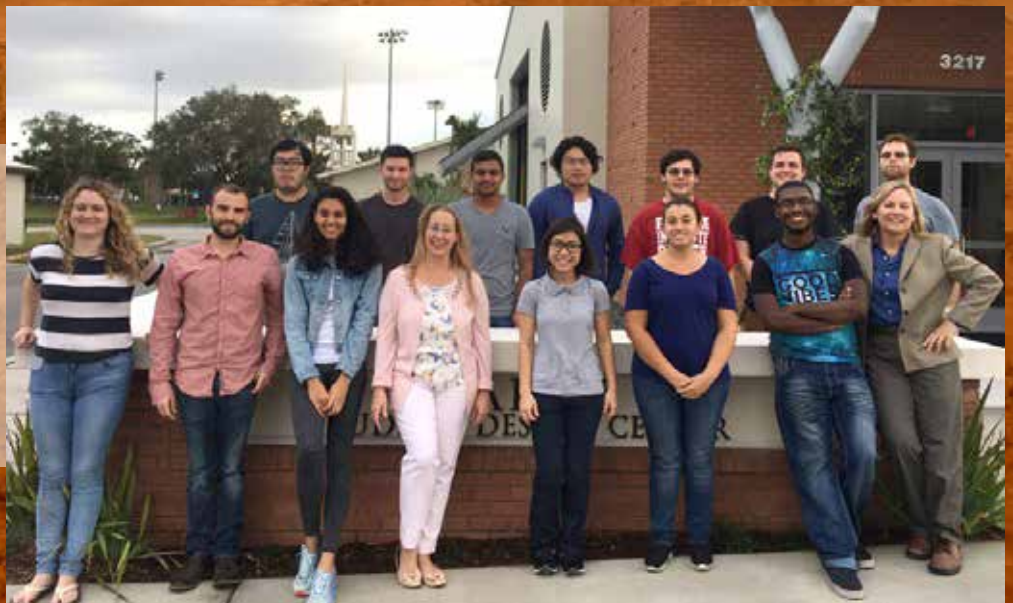


Colorado
School of Mines

**Embry-Riddle
Aeronautical
University**



**Florida Institute
of Technology**



**Illinois Institute
of Technology**





**Iowa State
University**

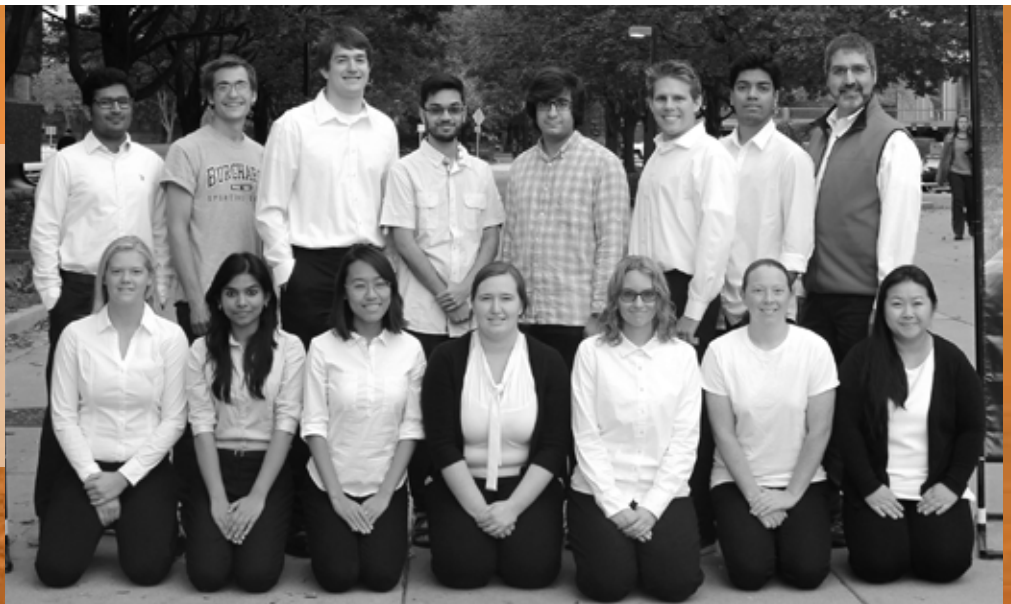


**John Brown
University**



**Kent State
University**

Milwaukee School of Engineering



Mississippi State University



Montana State University





Montana Tech



New York
University
Tandon School of
Engineering



North Dakota
State University

**Oakton
Community
College**



**Polytechnic
University of
Puerto Rico**

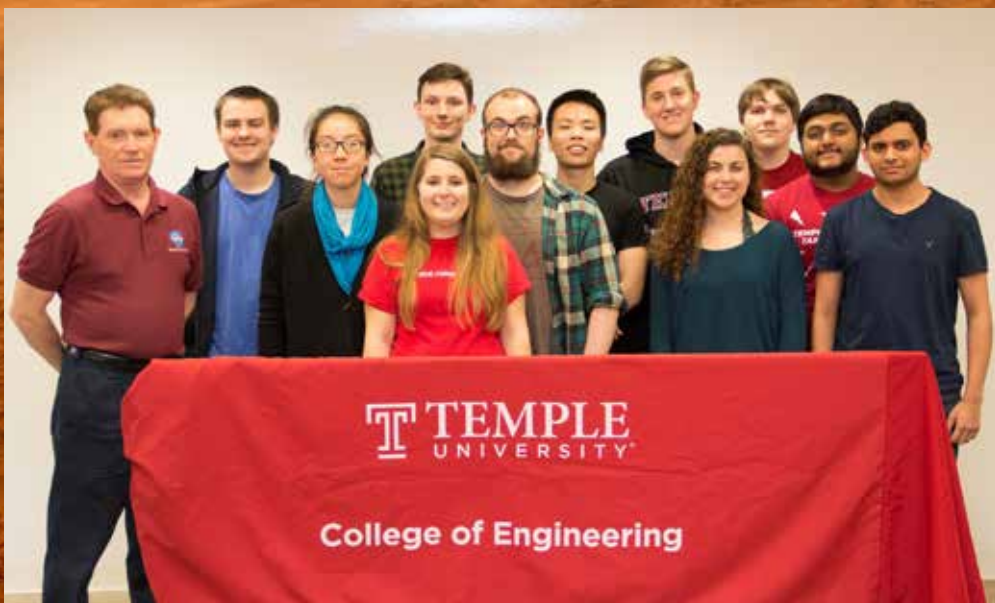


Purdue University





**South Dakota
School of Mines
& Technology**



**Temple
University**



**Texas A&M
International
University**

The University of Akron



The University of Alabama

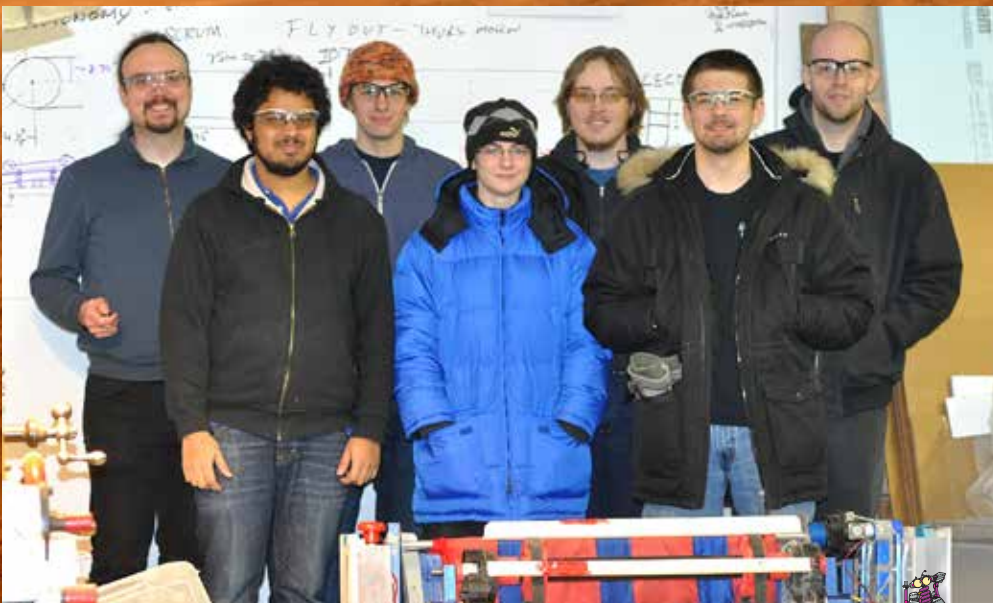


The University of North Carolina at Charlotte

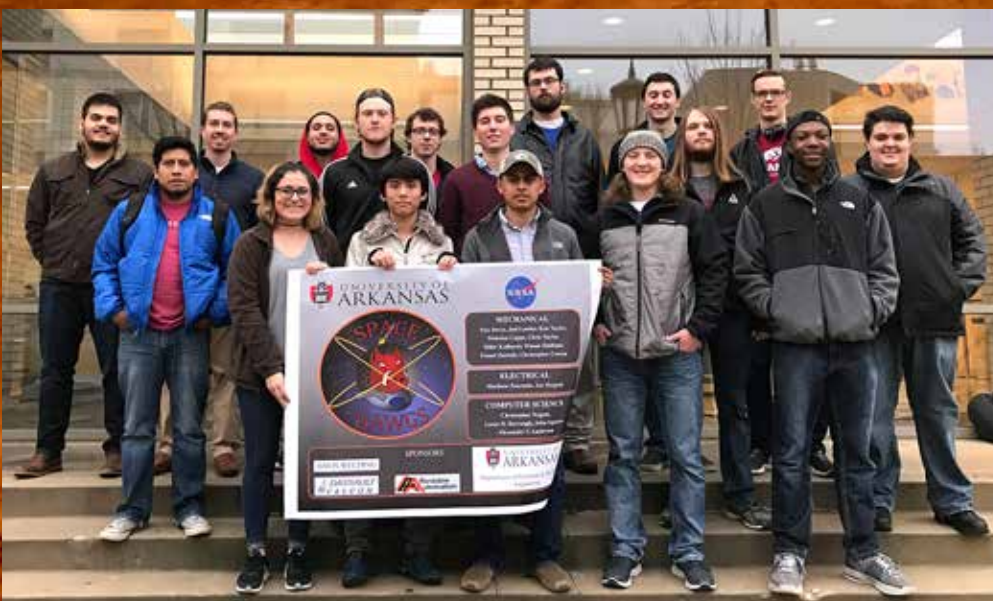




The University
of Utah



University of
Alaska Fairbanks



University
of Arkansas

University of
Central Florida



University
of Colorado
Boulder



University
of Florida





University of
Hawaii-Hilo



University
of Illinois
at Chicago



University
of Illinois
at Urbana-
Champaign

University
of Kentucky



University
of Michigan

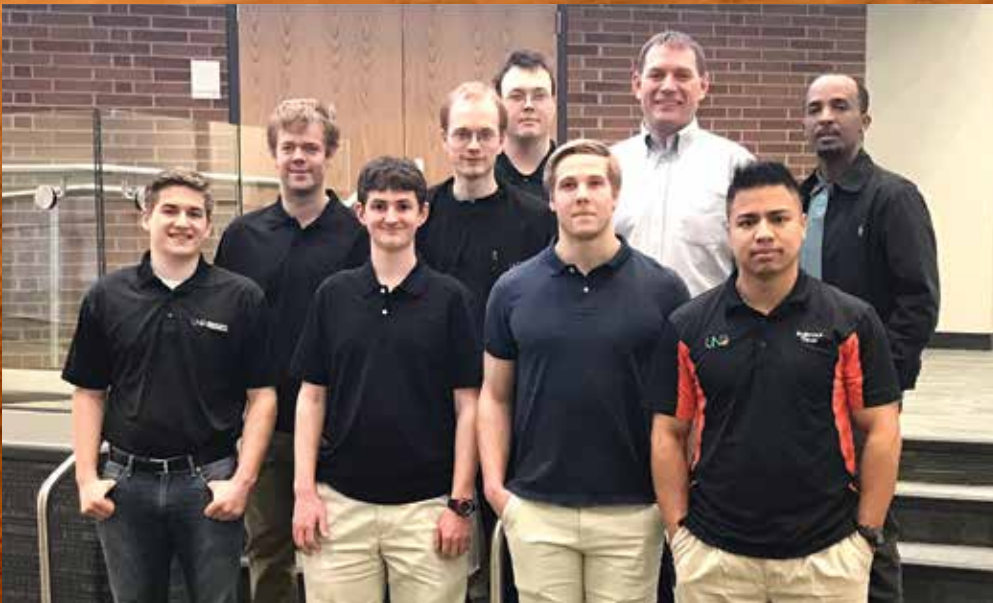


University
of Nebraska-
Lincoln





University of
New Hampshire



University of
North Dakota



University of
North Florida

University
of Virginia



University of
Washington
Bothell



University of
Wisconsin-
Madison





Virginia State University



Virginia Tech



West Virginia University

Worcester
Polytechnic
Institute



Wright State
University



York College



Judges

MINING



Rob Mueller
Lead Mining Judge



Tom Ebert



Marc Gramlich



Lisa Guerra



John Hamilton



Michael Johansen



Richard Lynch
(also SEP)



Lisa May
(also SEP)



Philip Metzger



Joe Minafra



Kristian Mueller



AJ Nick



Eric Reiners



Jason Schuler



Luke Setzer



Drew Smith



Kim Stratton
(also SEP)



Jeff Volosin
(also SEP)



Communications Support Team

Nathanial Cain
Michael Downs
Isaac Hutson

Michael Miller
Tom Nguyen
Marc Seibert

COMMUNICATIONS



Bill Dearing
Lead Communications Judge



Juan Busto



Philip Michaels



Jamie Peer

PRESENTATION



Daniel Hull
Lead Presentation Judge



Rebecca Mazzone
(also SEP)



Creg Raffington

OUTREACH PROJECT



Bethanné Hull
Lead Outreach Project Judge



Sandra Ames



Jerry Bernfeld



Tiffany Boyer



Denise Coleman



Tiffany Fairley



Al Feinberg



Christopher Giersch



Amanda Griffin



Meghan Guethe



Clarissa Lee



Mary MacLaughlin



Tori McLendon



Matthew Miller



Jane Mosconi



Anthony Sanders



Joshua Santora



Wayne Saxer



Ali Shaykhian



Angelo Thomas

SYSTEMS ENGINEERING PAPER



Jonette Stecklein
Lead SEP Judge
(also Mining)



Tim Brady



Linda Bromley



Mike Conroy



Nanette Faget



Montgomery Goforth



Roger Mathews



Rebecca Mazzone



Gloria Murphy



Erik Nilsen



Mark Powell



David Reeves



Chris Roberts



Dennis Rohn



George Salazar



Vanessa Stroh



Bruce Wiegmann

Photos Unavailable

Mining:

*Joe Beardall
Joe Forcash
Nathan Gelino
Matt Nugent
Derrick Pitts
Van Townsend*

Outreach:

*Marcia Groh Hammond
Priscilla Moore
Tai Victor*

SEP:

*Jon Arenberg
James Schier*

Presentation:

Justin Speichinger

COMPETITION STAFF



Lilianna Villareal
Arena Chief



Grace Johnson
Pit Crew Chief



Kurt Leucht
EMCEE



Richard Johanboeke
Project Manager

The Robotic Mining Competition Sponsored by NASA's Human Exploration and Operations Mission Directorate (HEO)

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Secor Strategies, LLC

Atlantis Education

Special Thanks to...

AV Matters

Many, many thanks to all the people who worked to make the Robotic Mining Competition happen:

NASA Communication & Public Engagement
Robotic Mining Competition Planning Team

Secore Strategies, LLC

KSC Infrastructure

Visitor Complex Staff

Graphics and Printing

Health and Safety

Arena Set-Up Crews

IT/Communications Crew

Judges

Press Site

Volunteers

Take-Down Crews

...and many others who worked behind the scenes!

THANK YOU!

CATERPILLAR

